$\nu_\mu \rightarrow \nu_e$ MC Studies

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Talk Outline

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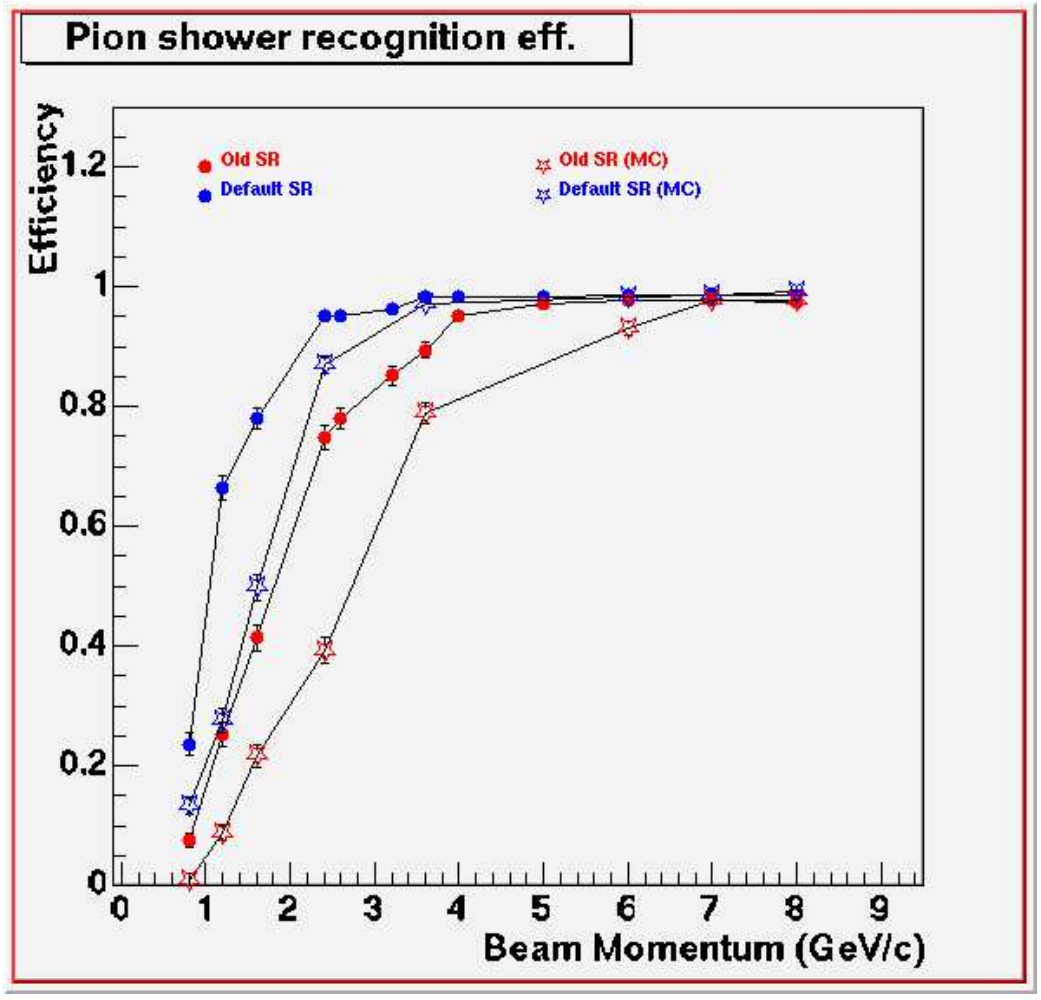
1. First stab at $\nu_\mu \rightarrow \nu_e$ reduction using Roy's "Standard" Reconstruction (SR).
2. Trigger Efficiency Study

π Shower Efficiency by S. Boyd



- Improved π shower efficiency (this tuning used here).
- Data/MC discrepancy (Data more efficient).

Application of SR to $\nu_\mu \rightarrow \nu_e$

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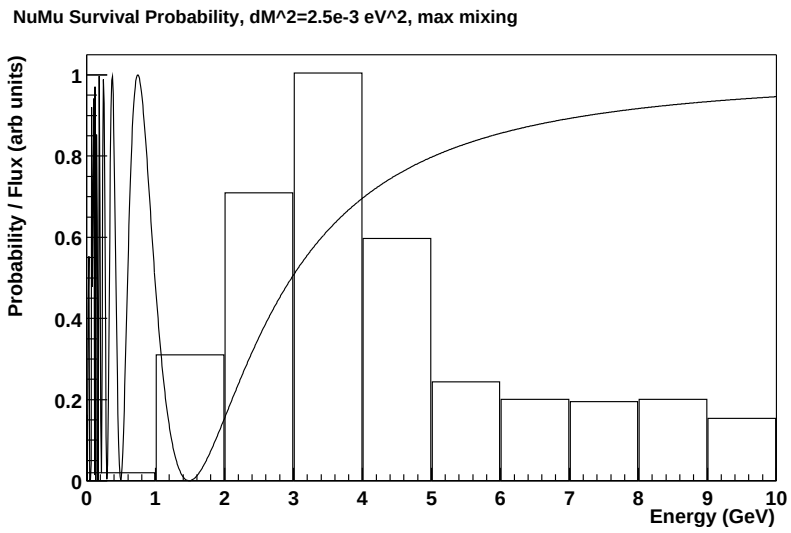
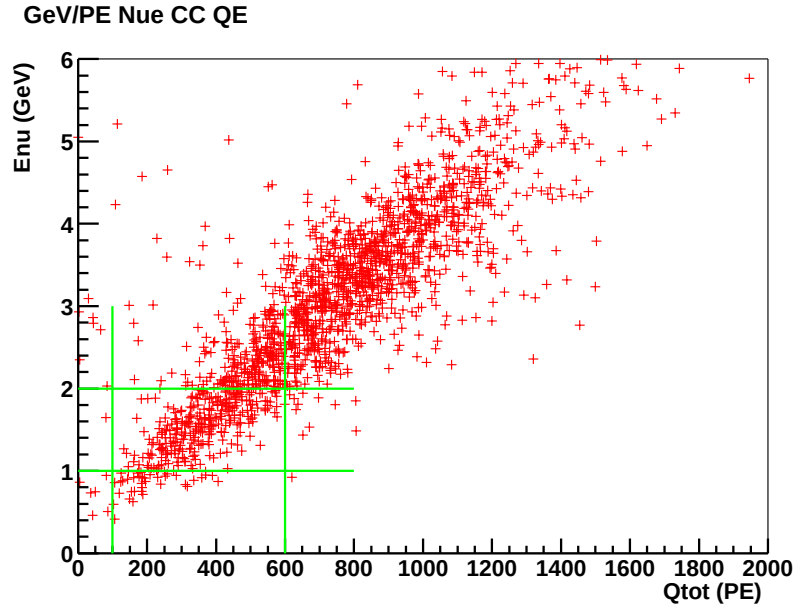
MC Samples and procedure:

- Look at ν_e CC QE, NC and ν_μ CC interactions.
- 25K LE beam events with **100%** $\nu_\mu \rightarrow \nu_e$. Used for ν_e CC QE and NC interactions.
- 25K LE beam events w/out oscillation. Used for ν_μ CC interactions.
- Production reconstruction job + SR shower algorithms.
- Qtot spectra and efficiencies.

Reminder of the energy range of interest



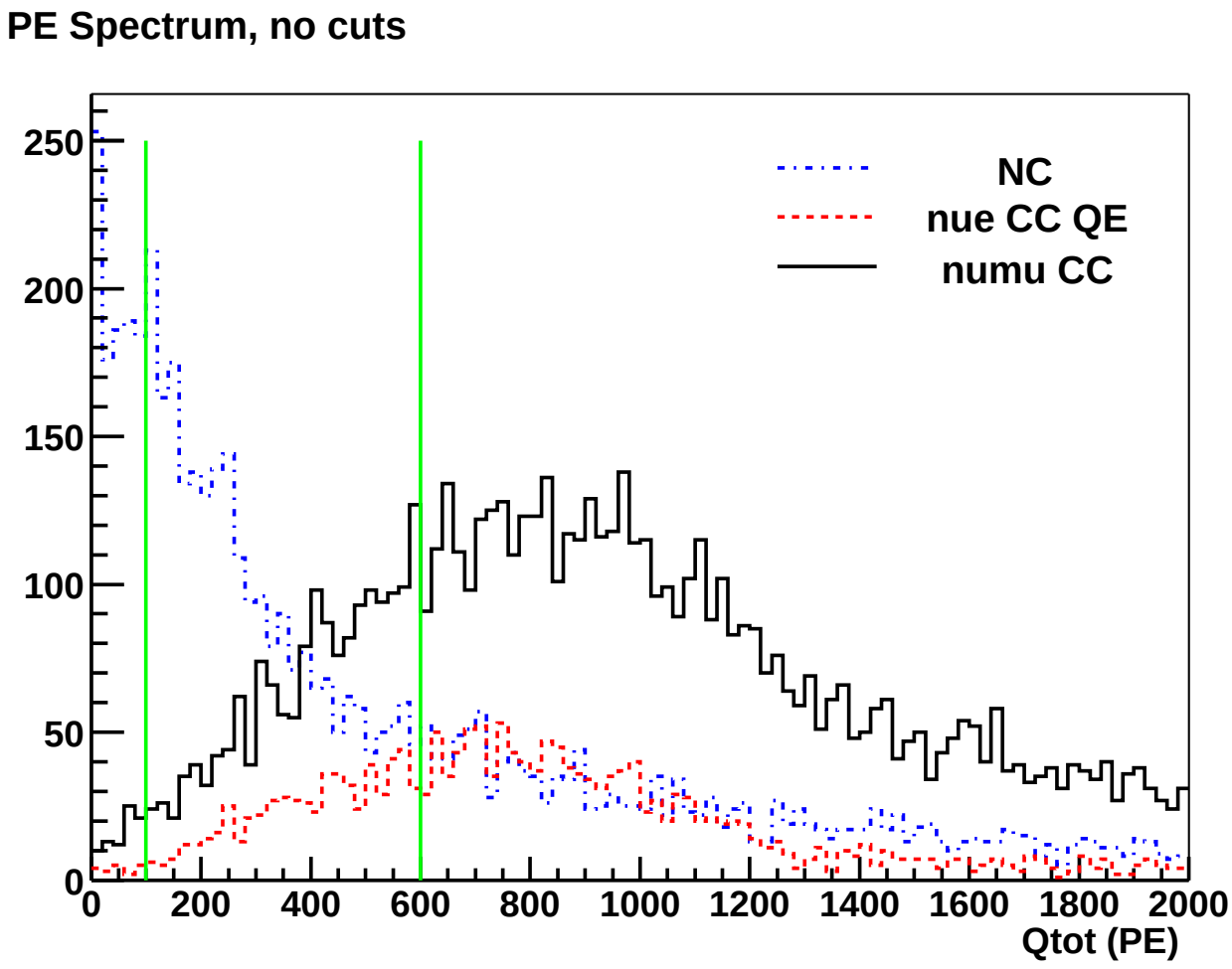


ν_μ disappearance node at SK point,

$\Delta m^2_{32} = 2.5 \times 10^{-3}$ eV^2, is at ~1.5 GeV.

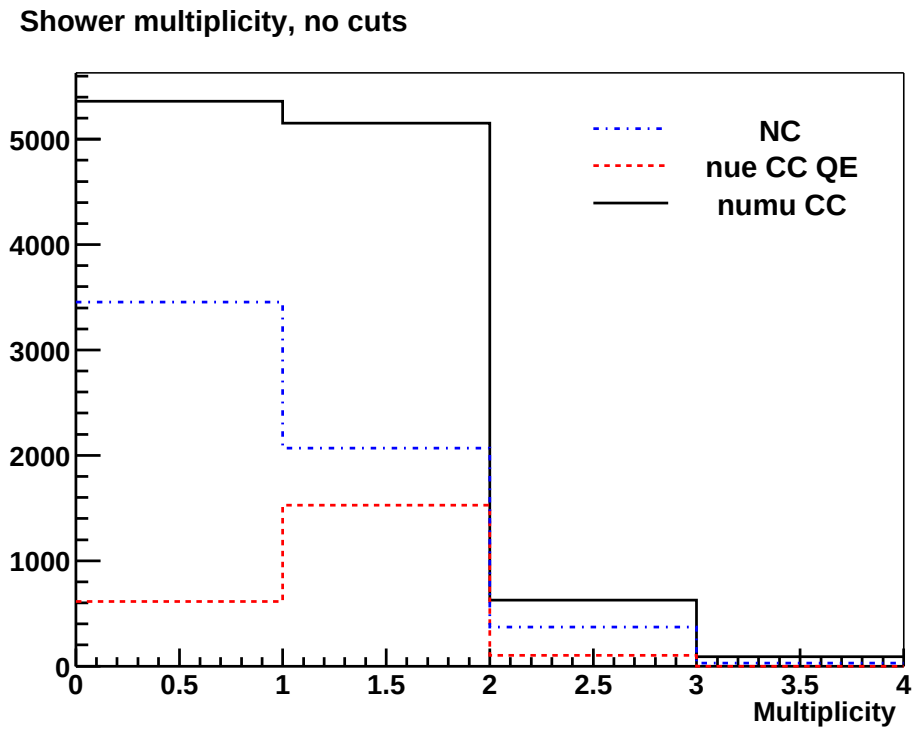
The 1-2 GeV bin corresponds to ~100-600 PE.

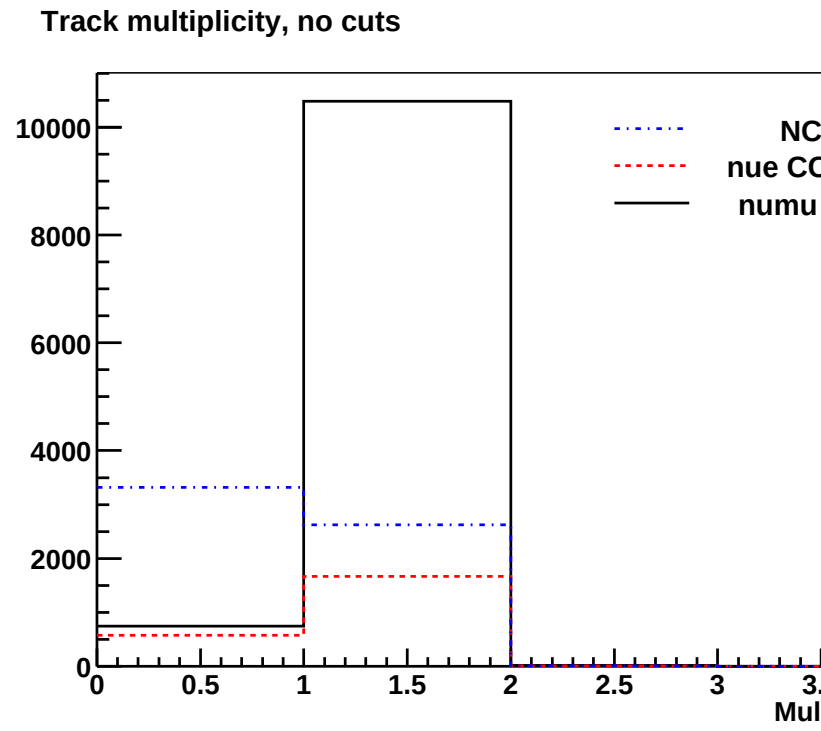
Raw PE Spectrum



Green lines contain the 1-2 GeV region.

Shower and Track Multiplicity

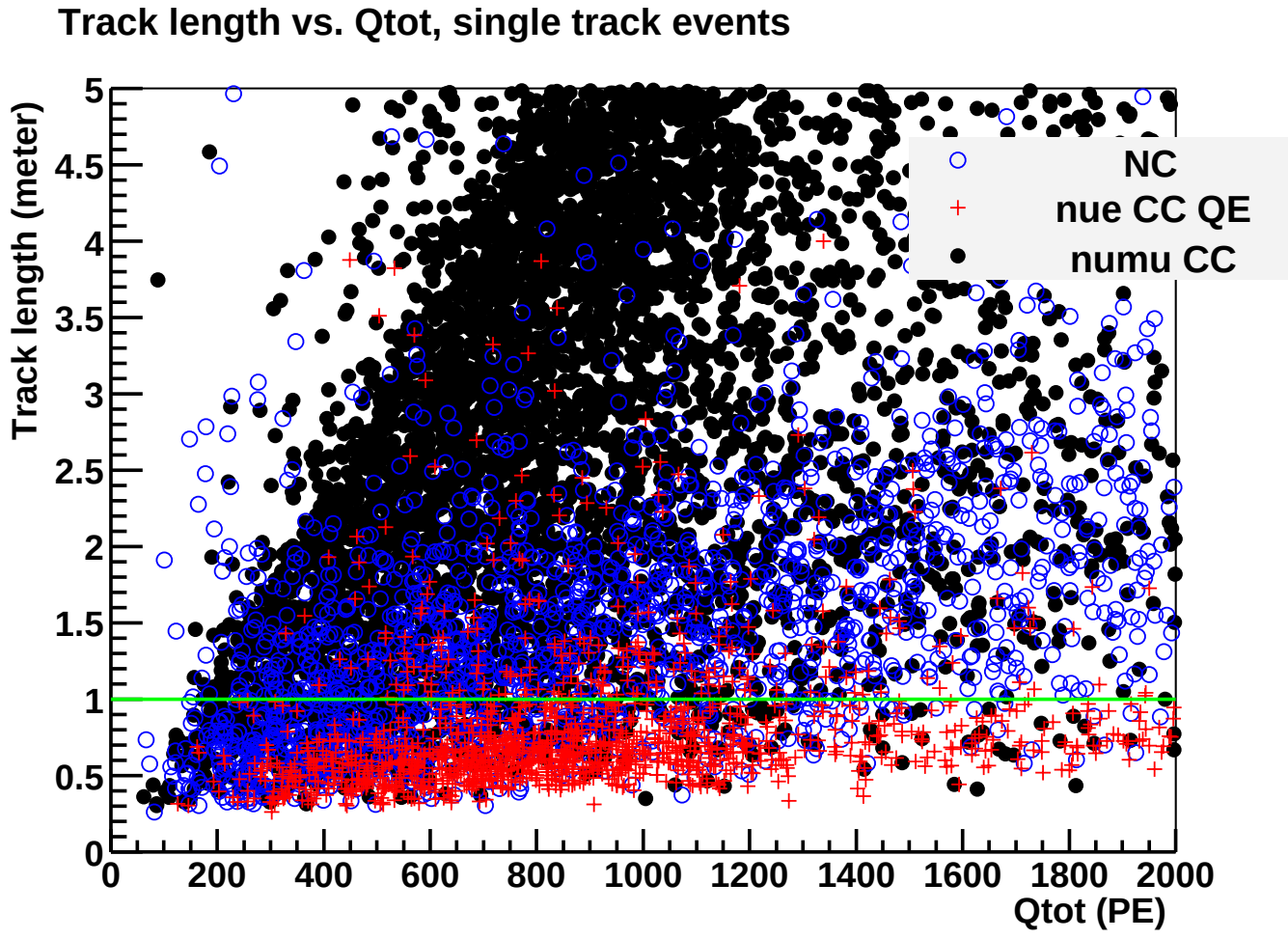




$\sim \frac{1}{4}\ \nu_e$ CCQEs have no showers found.

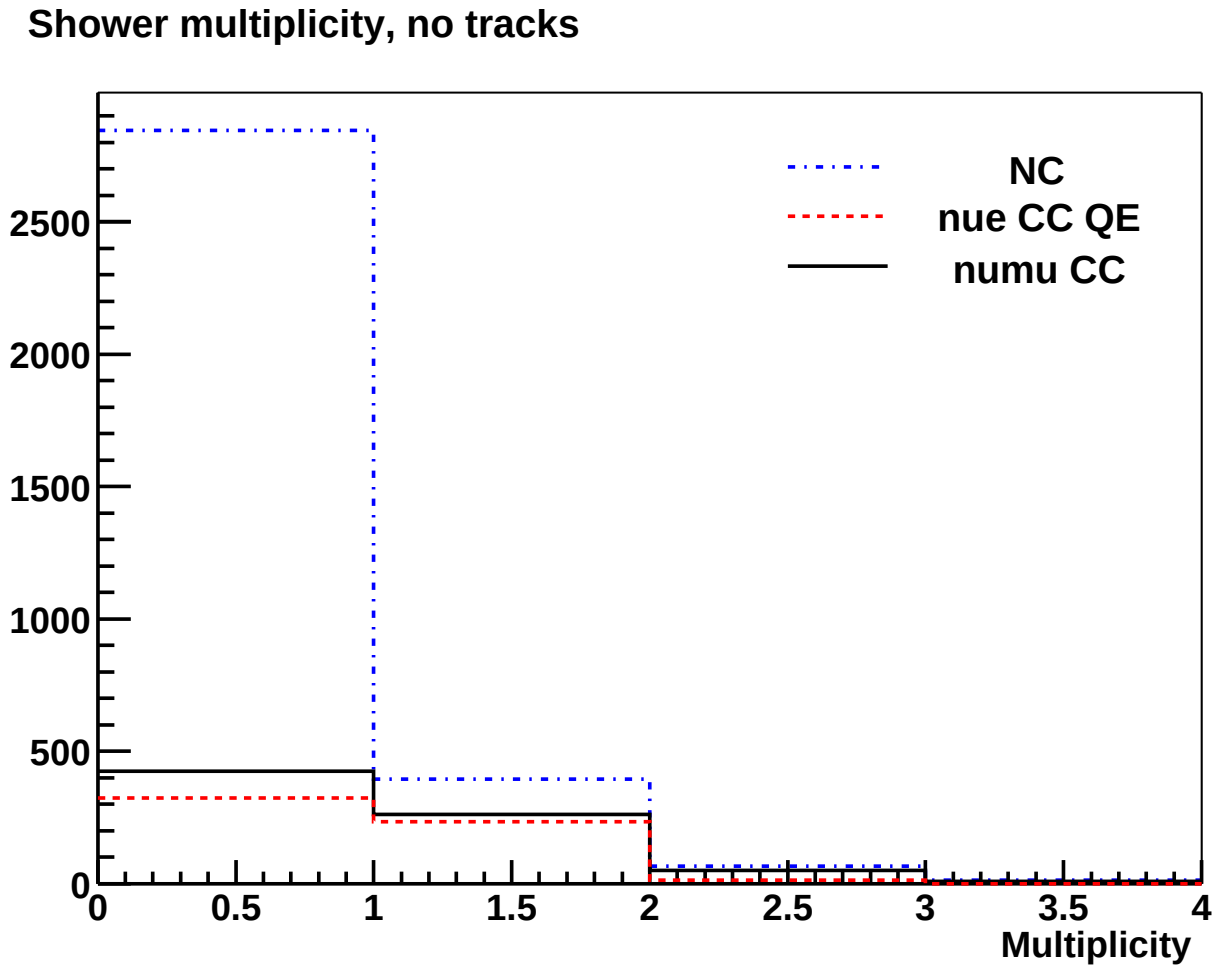
Majority of ν_e CCQEs have one track found.

Track Length for 1 track events



Cut: single track events with track length > 1m.

Shower Multiplicity for 0 track events



Require: events have 1 shower.

Simple Cuts

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Require:

1. Fiducial: $10 \leq$ plane ≤ 464, $\rho_{vtx} \leq 3.5m$
2. 1 track events: length $\leq$ 1 m.
3. 1 reconstructed shower.

Next, resulting spectra and efficiencies for ν_e CC QE, NC and ν_μ CC interactions.

Effects of cuts on ν_e CC QE spectrum

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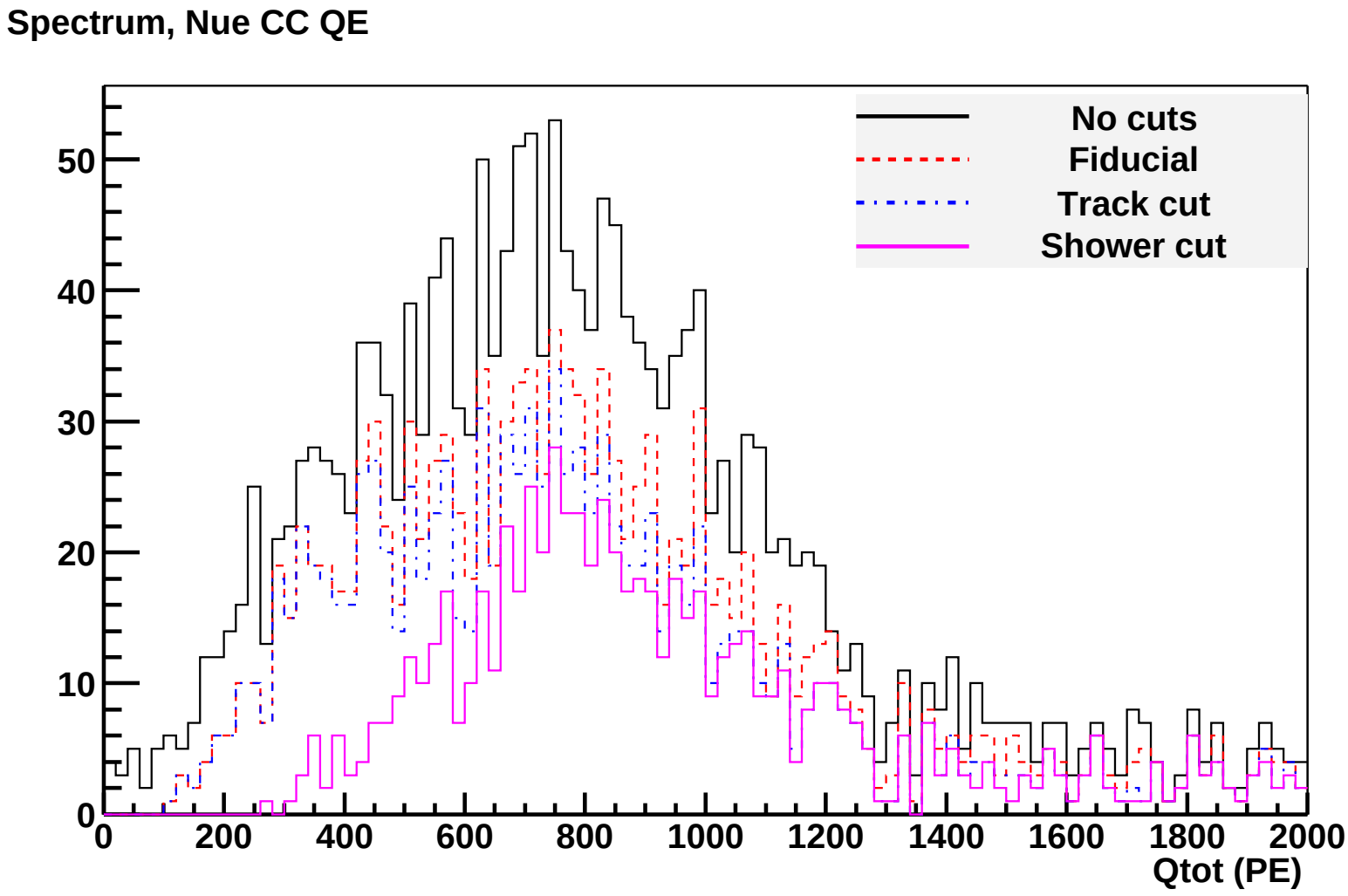
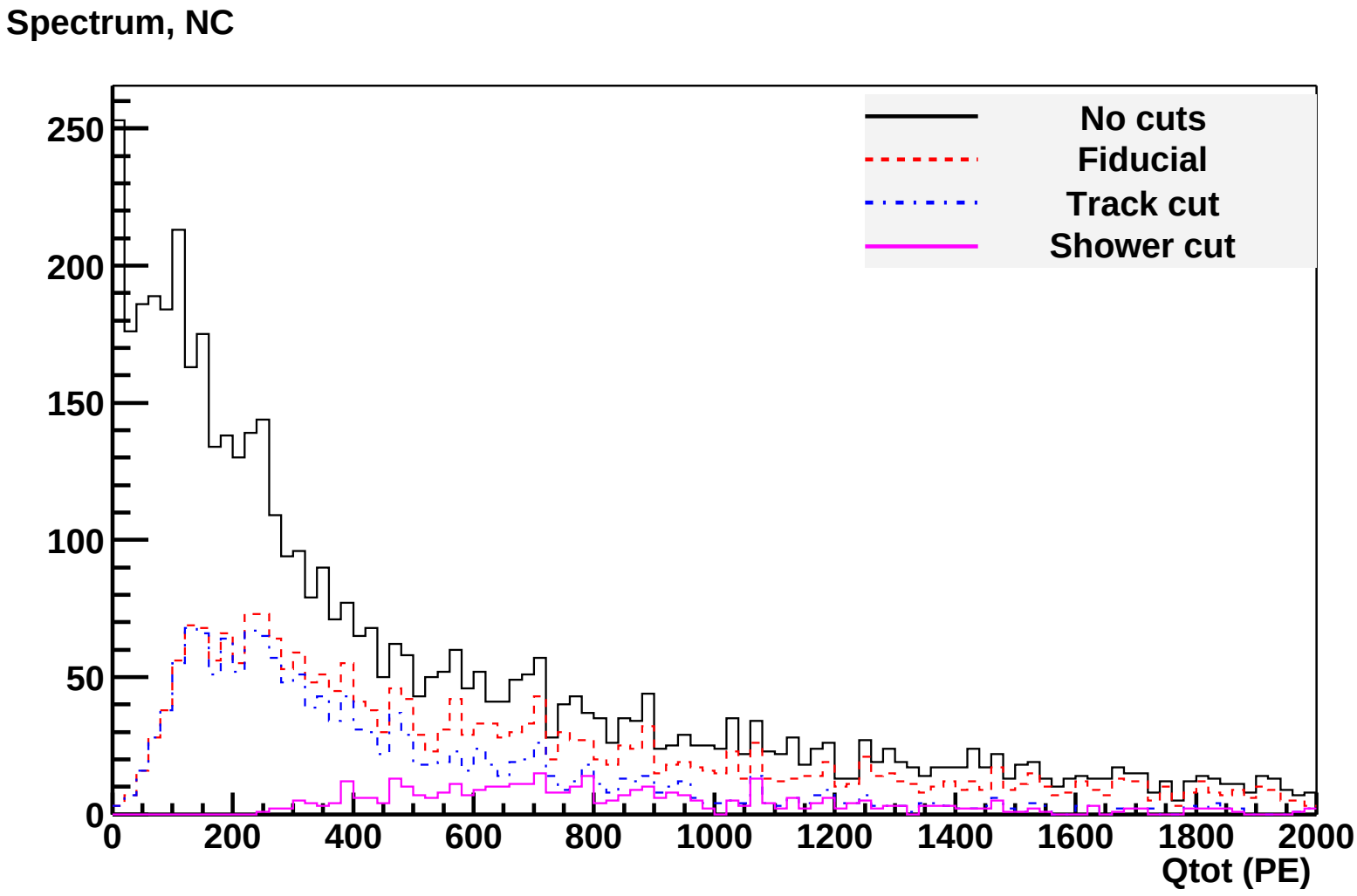


SR misses low charge showers.

Effects of cuts on NC spectrum



Improvement in SR shower eff. will also boost NC bkg.

Effects of cuts on ν_μ CC spectrum

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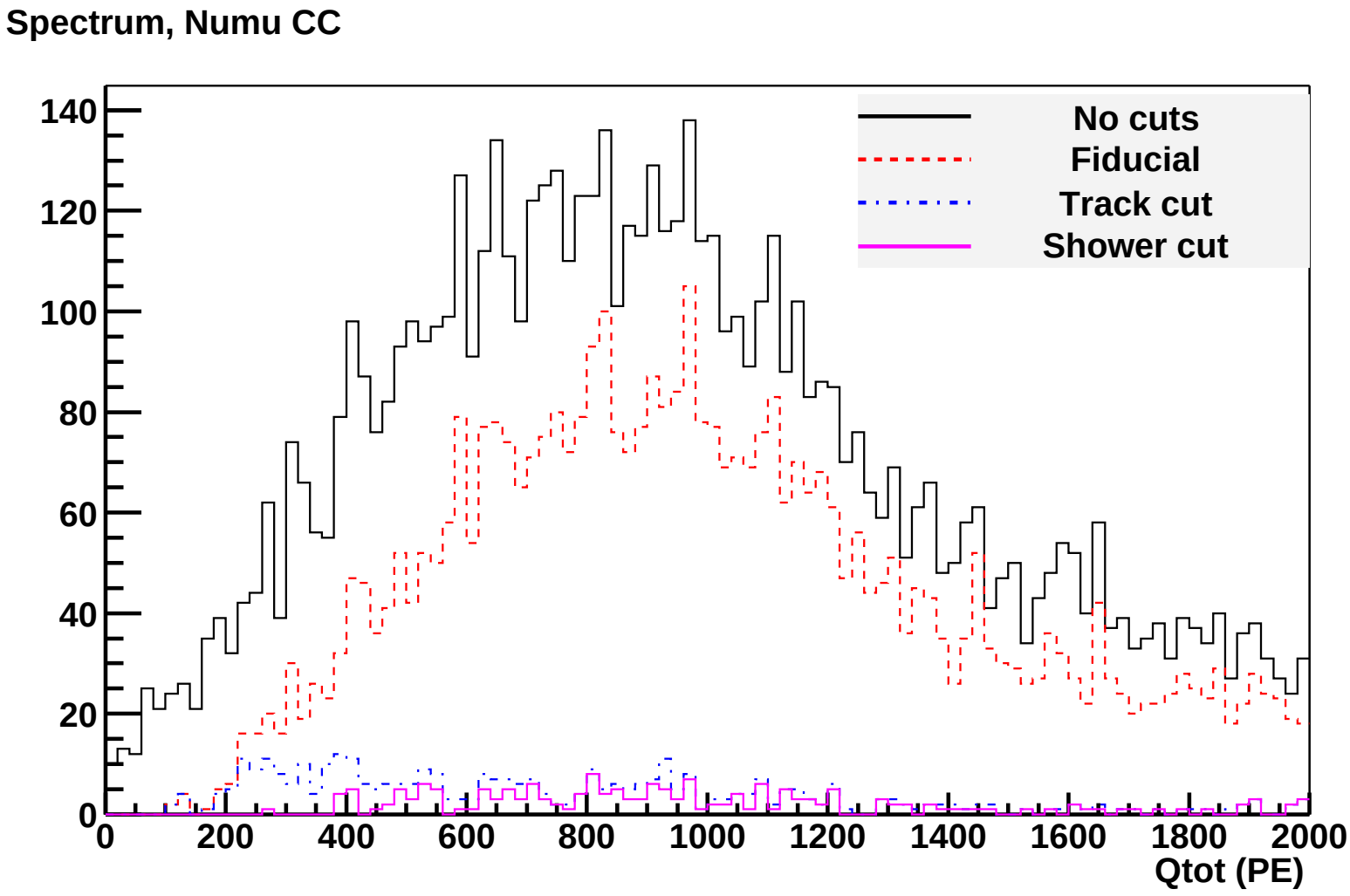

And ν_μ CC as well...

Effects of cuts on ν_e CC QE efficiency

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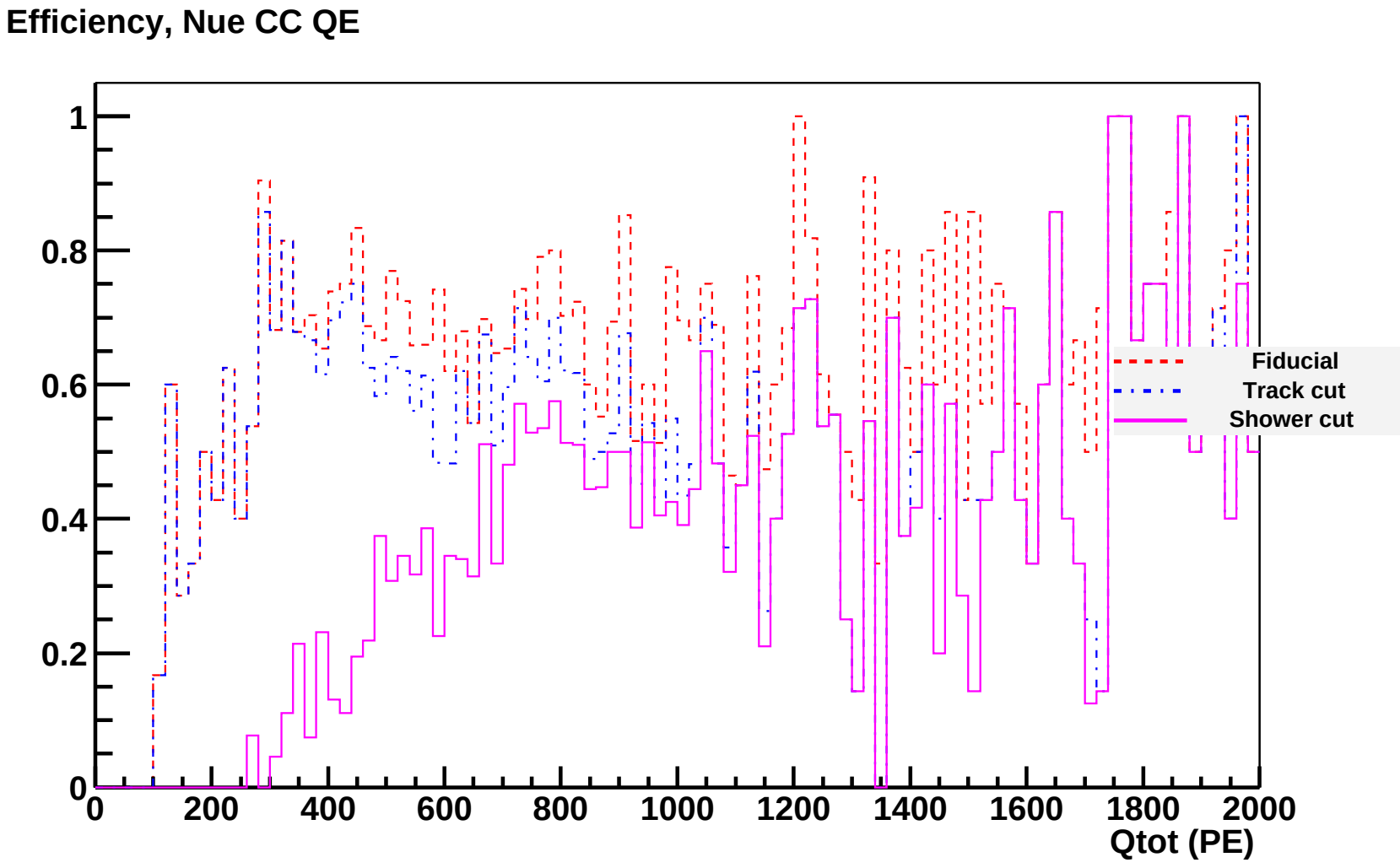
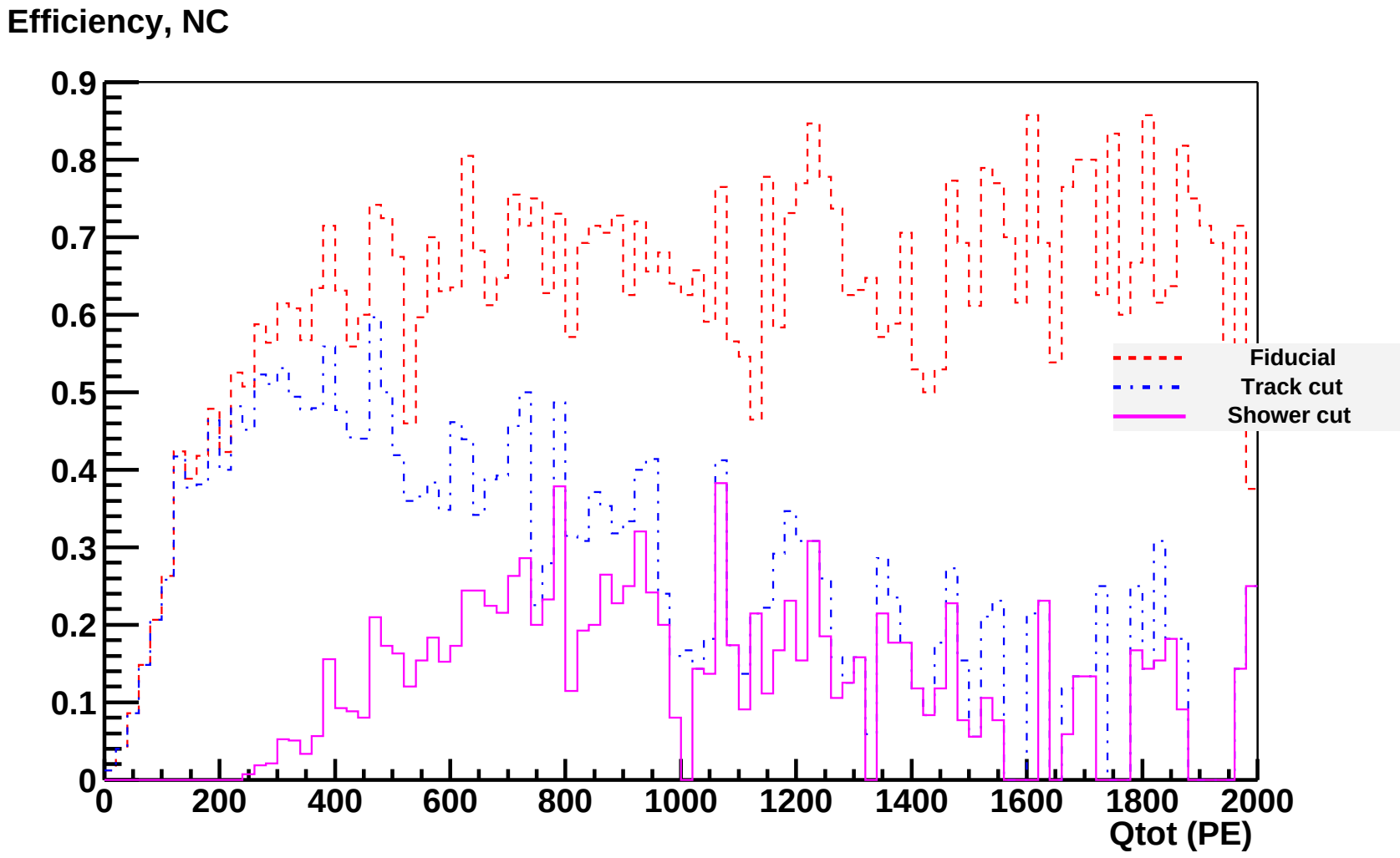


Effects of cuts on NC efficiency



Effects of cuts on ν_μ CC efficiency

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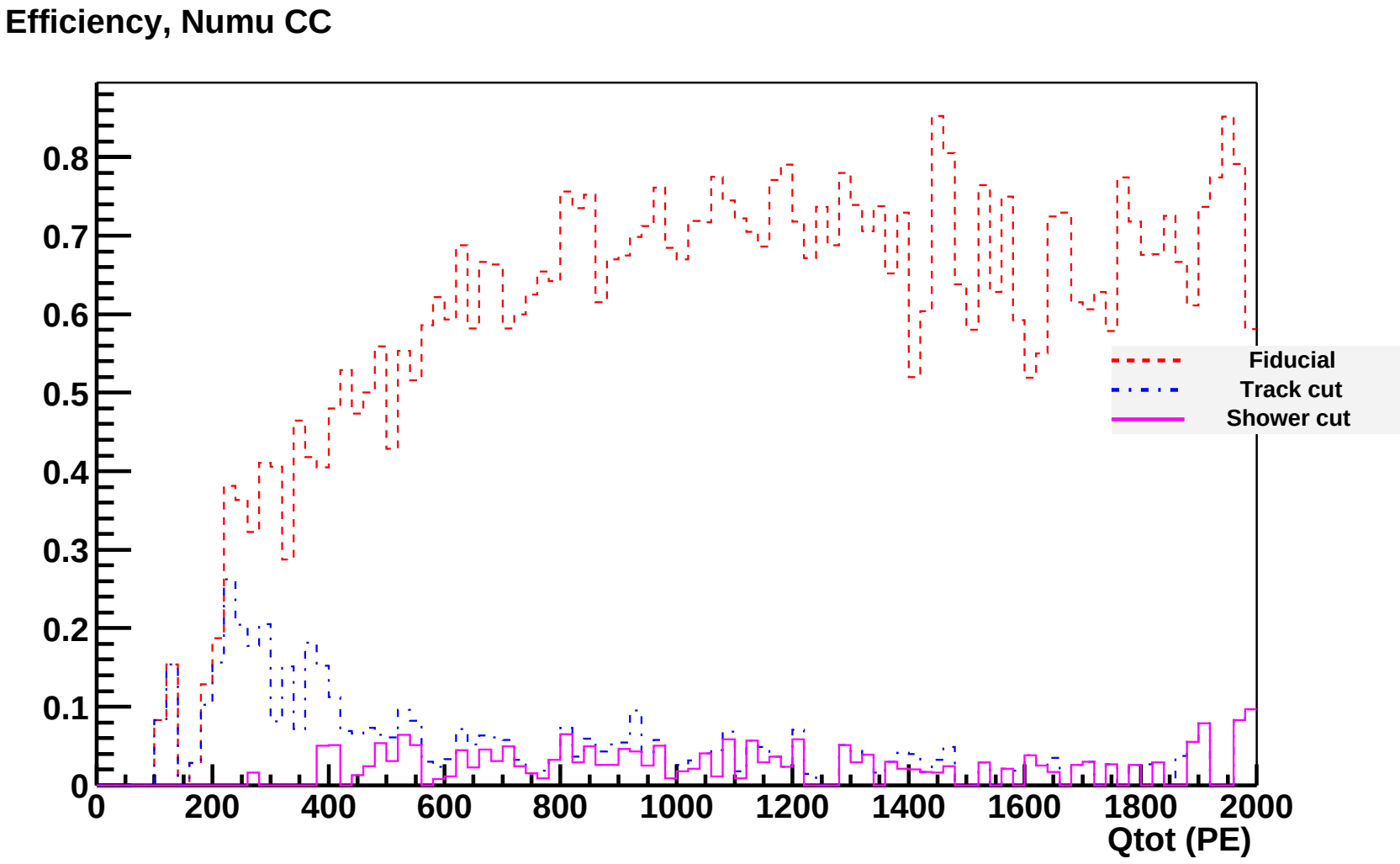

Non-flat fiducial cut? “plane” vs. “planeall”?

Trigger efficiency study

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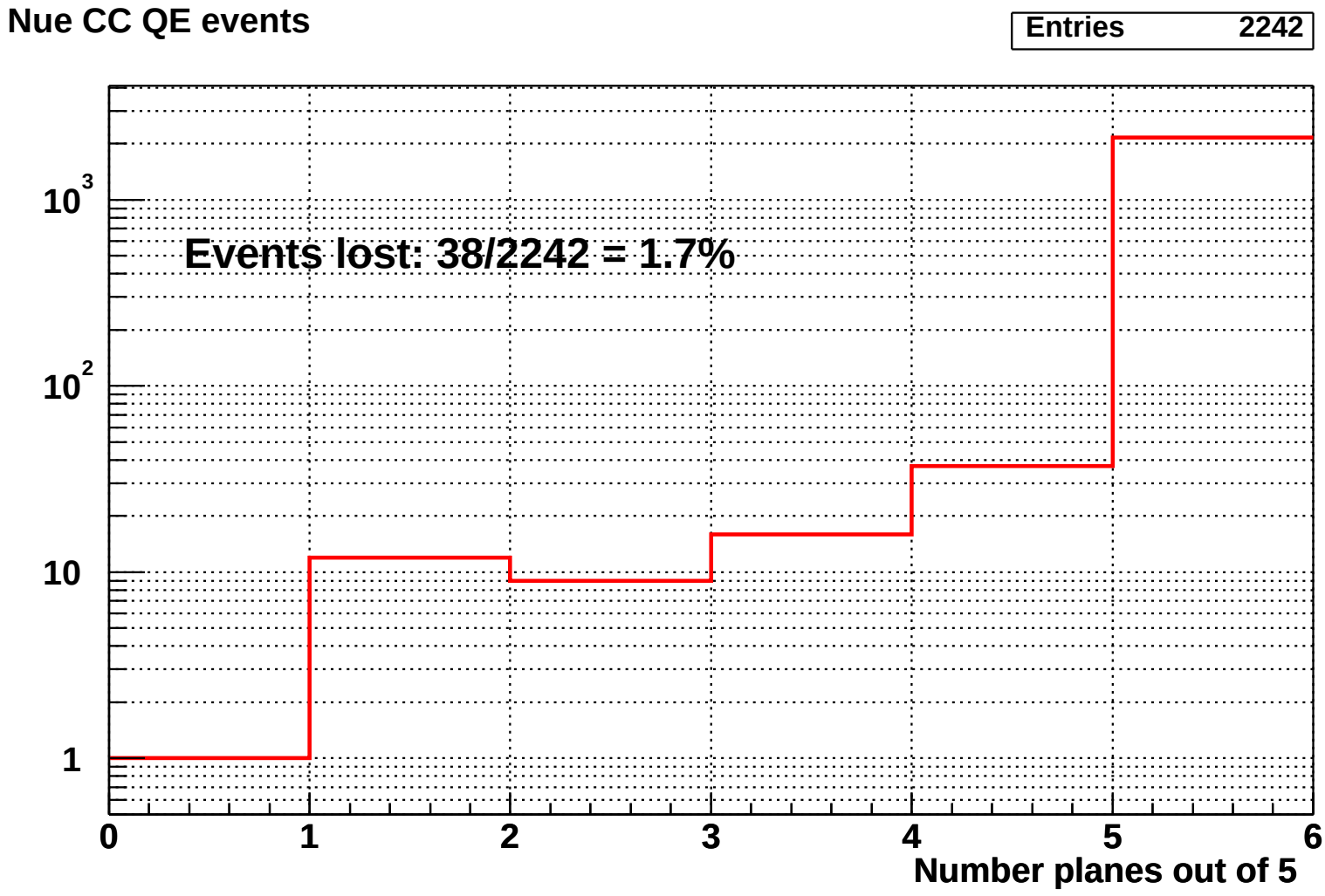
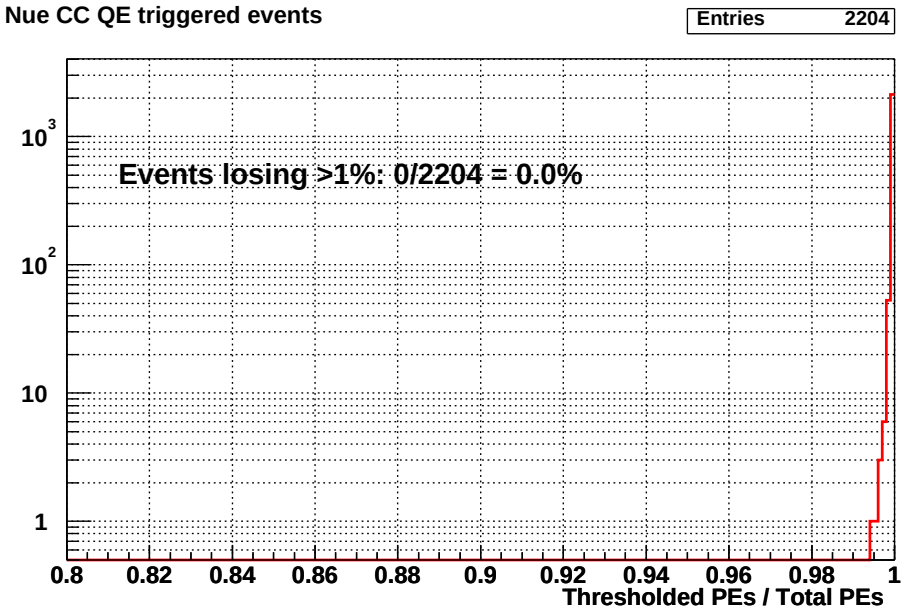
- Trigger as explained by Geoff:
  - Local VARC trigger: 2/N PMTs with dynode $>$ 1/3 PE. N=24-36.
  - Time order PMT pixels in triggered VARCS. Gap of 156.25 ns splits snarls.
  - 4 hit out of 5 consecutive planes.
- Simulated this in the offline.
- Applied to the 25K 100% $\nu_\mu \rightarrow \nu_e$ MC sample.
- Looked at lost events and lost energy for ν_e CC QE and NC.

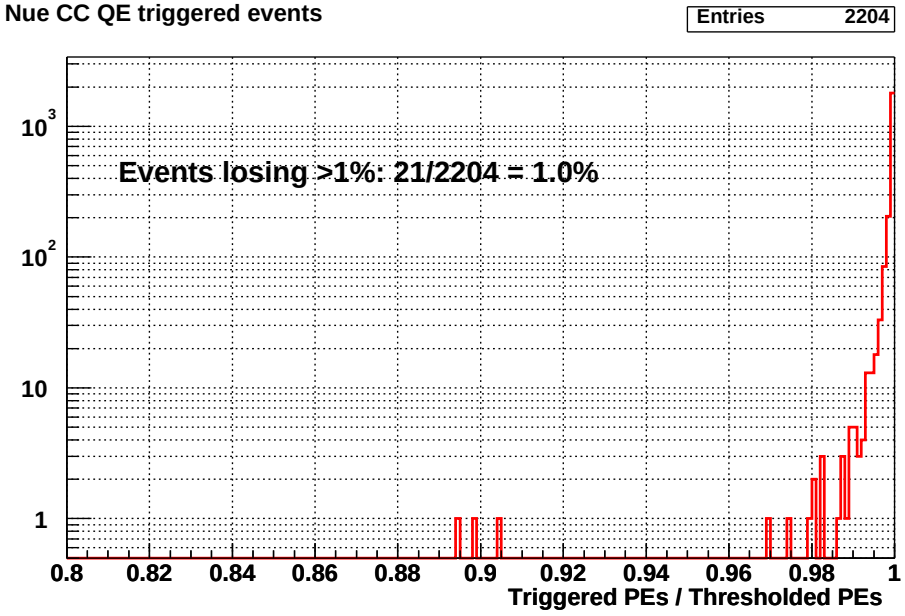
ν_e CC QE event loss



About $\sim 0.5\%$ vertices in last plane. $\sim$1% loss due to trigger.

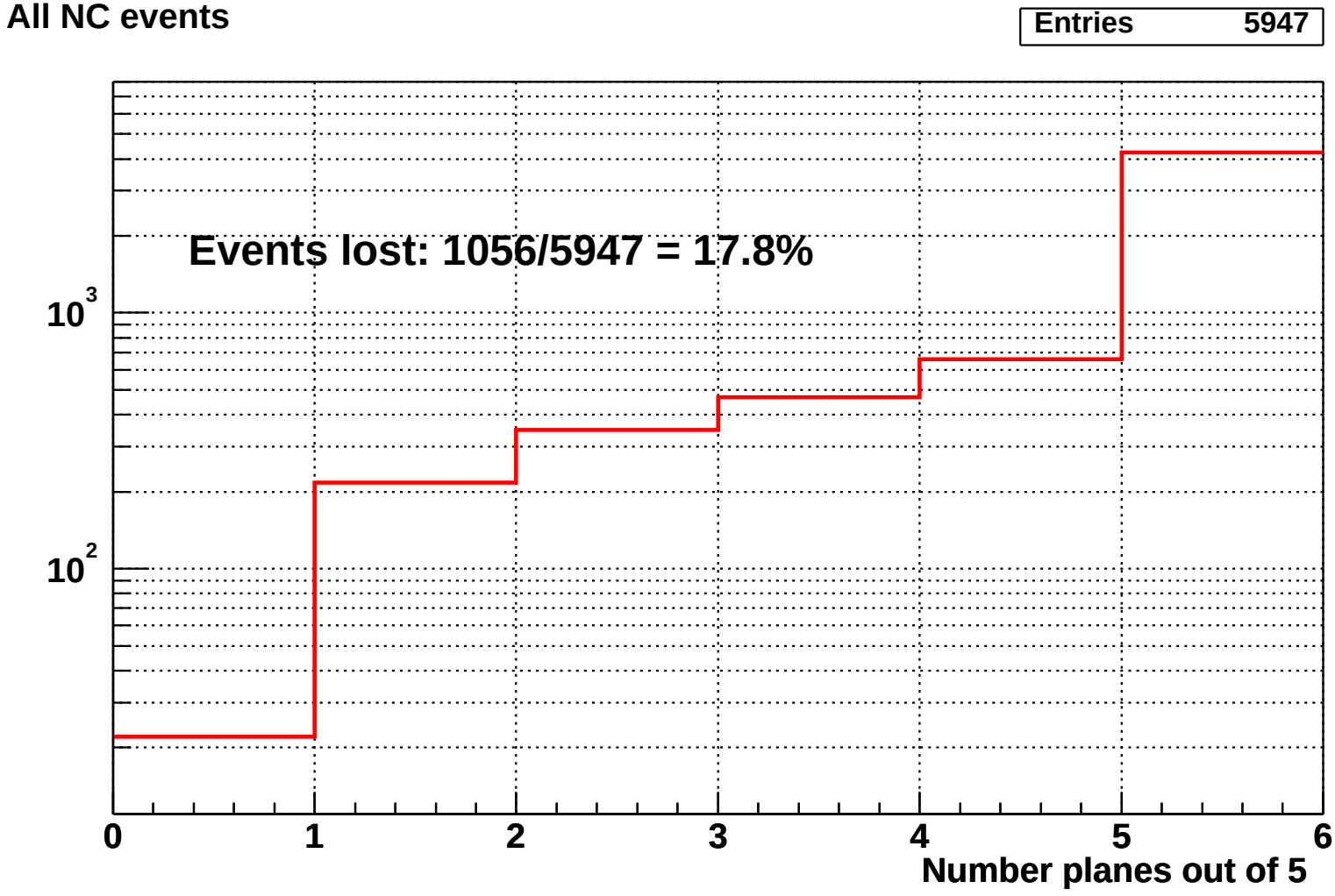
ν_e CC QE charge loss



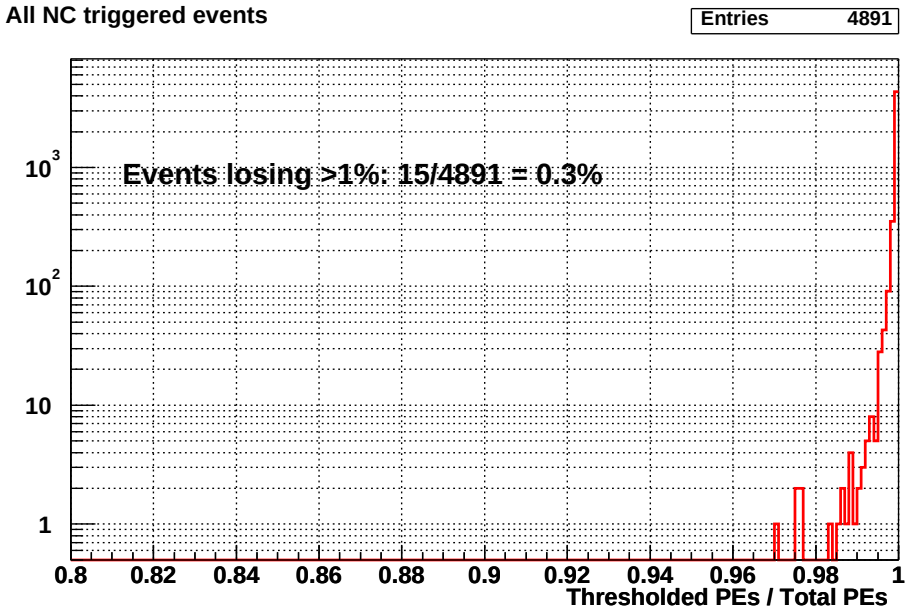


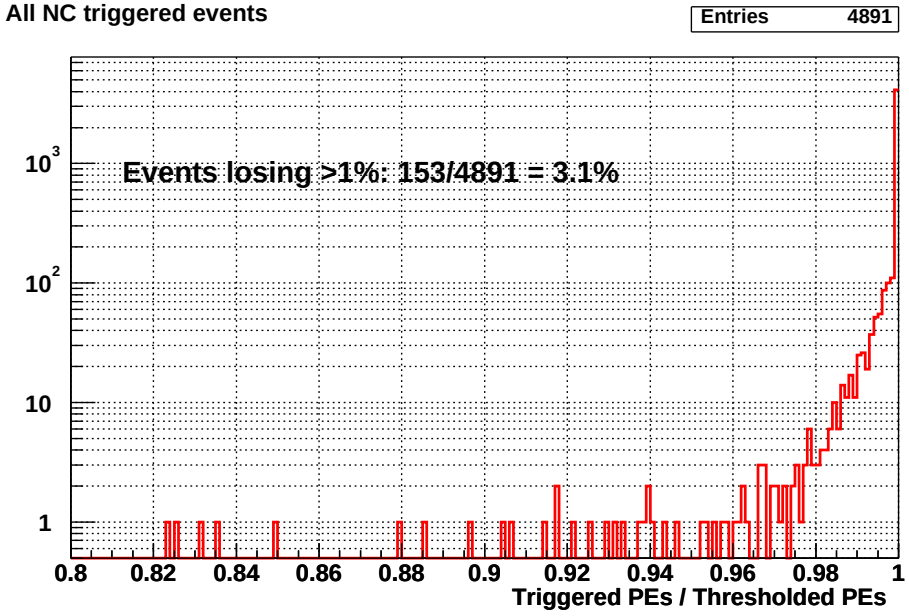
- No events with $>$ 1% charge loss due to 1/3 PE cut.
- 1% events loose more than 1% of their energy due to local VARC trigger.

NC event loss



NC charge loss





- Negligible events loose more than 1% due to 1/3 PE cut.
- 3% loose more than 1% due to local VARC trigger.

Conclusions

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- SR finds no showers in $\sim \frac{1}{4}$ ν_e CC QE, mostly in the low part of the 1-2 GeV bin.
- Requiring exactly one shower reduces background and signal alike. Improvements in SR shower finding will bring the need for other reductions.
- Track fits provide strong rejection for ν_μ CC above $\sim$2 GeV region (1 GeV used in NuMI 714).
- Efficiencies in region of interest:
  - ν_e CC QE: 10-60%
  - NC: 10-20%
  - ν_μ CC: few %
- Trigger efficiency okay for $\nu_\mu \rightarrow \nu_e$.

Possible Future Efforts

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- Improve on SR shower finder, deal with higher resulting background.
- New shower reconstruction methods (AtNuReco).
- “Non-reconstruction” methods:
  - Global event topology statistics
  - Neural net event classification (Athens)